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were manifestly absurd. The angles and distances of the several positions were laid down with all possible accuracy, but in order to avoid confusing the two sets, the scale of distances for the observed positions is one and one-half time the scale used in laying down the first positions. The divided scale of 1″·0 shown on the diagram has reference to the white circles.

Certainly these positions appear to show orbital motion beyond all question. If there is any doubt in regard to this, then it follows as a matter of course that no binary system is positively known as such, where the period is more than 300 years.

The ellipse shown on fig. 2 gives a period of 310 years. This may or may not be somewhere near the correct time. A variety of curves may be passed through these corrected positions, where the arc is only 90°, and represent them equally well. The most that can be said of this is, that the period will not be less than 300 years, while it may be considerably longer. Casey's period of 340 years can be made to suit these positions, but in other respects it would differ, and particularly in the eccentricity. It will be observed that the real orbit shown on the diagram is circular, while the computed orbit has an eccentricity of 0·30.

In the Albany Zone Observations (*Astronomical Journal*, No. 200) Boss gives the annual proper motion of the mean of the two components as 0″·184 in the direction of 277°·2. Assuming this to be the movement of the principal star, then if the relative change is due to proper motion, the companion would have an annual motion of 0″·197 in the direction of 283°.

Chicago :
May 10.

The Orbit of 40 *Eridani*, Σ 518. By S. W. Burnham, M.A.

The double companion to 40 *Eridani* was discovered by Herschel in 1783. It was next observed by Struve in 1825, but was too difficult to measure. The measures of precision really commence with the observations of O. Struve in 1851. Since that time it has been looked after by the various double star observers, and the arc of nearly 60°, through which the small star has passed in the last forty years, is very well defined, and the measures as a whole appear to be fairly satisfactory. The mean angular change has been about one degree and a half per year, but it is obvious that the apparent ellipse is a very elongated one, and therefore the average motion for a complete revolution will be a much smaller quantity.

Though the period is long, this is an interesting binary from the large proper motion of the system. Only four stars in the northern hemisphere have a larger proper motion. This is common to the principal star, and to the binary companion which is more than 80″ distant. Hall finds a parallax for A of 0″·22, so that the system is comparatively near the Earth.

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The only orbit of BC is by Gore (*Monthly Notices*, 1886 March), who used the measures down to, and including, 1883. He found a period of 139·0 years. Since that time additional measures have been made which are not well represented by the ellipse, and it is evident that this provisional orbit is not the best which can now be made.

I have collected from original sources all the observations, and give them in chronological order:—

	Date.	P.	D.	*n*	
1	1783·13	326°·7	Cl. II.	1	Herschel
2	1825·12	287	...	1	Struve
3	1851·06	159·9	3″±	1	Dawes
	·22	155·8	3·91	4	O. Struve
4	1855·06	154·0	4·14	6	O. Struve
5	1864·85	147·6	4·45	2	Winnecke
	1865·90	144·0	4·26	2	O. Struve
7	1869·10	140·4	4·46	1	O. Struve
8	1873·85	137·0	4·27	4	O. Struve
9	1877·84	128·2	3·92	6	Burnham
	·84	127·5	3·36	3	Cincinnati
	·95	126·4	3·94	4	Dembowski
10	1879·05	125·4	3·49	4	Burnham
	·11	122·9	...	1	Cincinnati
	·18	125·0	3·51	2	Hall
11	1879·75	120·0	3·29	1	Cincinnati
	80·09	121·3	3·28	5	Burnham
	80·95	122·0	3·16	5	Burnham
12	1881·84	119·0	3·53	6	Burnham
	2·12	118·1	3·24	2	Hall
13	1883·00	119·2	3·07	2	Burnham
14	1883·80	115·8	3·10	2	Hall
1	1886·00	112·2	3·22	2	Leavenworth
	·09	112·2	3·00	6	Hall
	·92	111·0	3·01	3	Tarrant
16	1888·12	107·7	3·04	5	Hall
17	1888·84	106·8	2·94	3	Burnham
	8·87	105·0	2·81	3	Tarrant
	9·12	103·5	2·79	4	Hall
18	1890·73	100·0	2·68	4	Burnham
	1·05	98·5	2·65	5	Hall
19	1891·78	97·4	2·48	4	Burnham

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The two angles of Herschel and Struve, and the seventeen positions derived from the measures, as shown above, are accurately laid down on the diagram, plate 10. When more than one set of measures is used, as indicated by the brackets and corresponding marginal numbers, a simple mean is taken.

Now it is obvious that it is impossible to obtain by any method the real or apparent orbit of this pair from an arc of only 60°. A great variety of ellipses could be made which would represent these positions equally well, and which would differ widely from each other in every element. The angles of Herschel and Struve are the only means we have of deciding upon the particular form of ellipse which shall be taken to represent the orbit. In doing this it is necessary to carefully weigh the probable relative values of these angles, because it is certain that if we put all of the observations on the same footing, and distribute the errors as equally as possible over the later accurate measures and the somewhat uncertain early angles, the result will not be reliable. In 1783, when Herschel discovered this pair, it must have been a very easy object, as from the estimated distance he placed it in Class II. (4″ to 8″). He appears to have made only a single measure of the angle, but in a pair as wide as this, that should give it within a few degrees at most of the true value, even from a rough setting of the wires. Therefore we may assume that the distance was not less than 4″, and that the angle was not far from 326°. It is unfortunate that he did not make some attempt to measure the distance. Even a careful estimate at that time would be of great value now, since the errors of estimation should not much exceed 1″ in a pair of this kind.

In the position for 1825 there is much more uncertainty. This is about the only star of the class in Struve's *Mensuræ Micrometricæ* which he was unable to measure. It is not given in its proper place as a close pair in this work. It is mentioned in the section where the distant star is treated (p. 275), and again in that part of the introduction which relates to proper motion (p. cxi). It must have been seen with extreme difficulty, as otherwise it would have been observed in the usual way, and given its proper place under his Class II. in the Catalogue. The angle which he gives seems to have been regarded heretofore as some sort of measure, since one would hardly attempt to estimate a position-angle, even of the easiest pair of stars, so closely as to give it 287°. When we examine *Mensuræ Micrometricæ* carefully the explanation is very obvious. We find that this angle not only does not purport to be from a measure, but is not even an independent estimate. At this time Struve measured the angle of B from the large star, and obtained 107°. He evidently regarded C as being very nearly in line with AB, and consequently called the angle 287°. Therefore I think that all we are justified in inferring from this observation is that in 1825 the companion

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was somewhere on the preceding side, and that the pair was close, and excessively difficult with the Dorpat telescope.

In drawing the ellipse to represent the apparent orbit there are two conditions to be met. First, it must represent as accurately as possible the observed positions from 1851 to 1892, and in this respect nothing must be sacrificed to make it conform to the earlier position-angles; and, secondly, the eccentricity and the length and direction of the major axis must be such that the areas of 1783 to 1851, and 1851 to 1892 are, as nearly as possible, proportional to the times. The uncertainty of the angle of 1825 is so great, it should not be used in determining the form of the ellipse. The result is far more likely to be correct when the other observations are depended upon.

Gore's orbit is shown on the diagram by the dotted ellipse. He has evidently made it conform to Struve's angle in 1825, since the error of that angle is only 5°·3, but in doing so it was necessary to sacrifice to some extent the measured positions of 1851 to 1883. It is obvious that this ellipse does not represent the distances at all satisfactorily. Ten of the distance measures require corrections of from 0″·70 to 0″·93. It would seem that measures by these observers, of a pair of this kind, should not have these large errors.

With the considerations in view which I have mentioned, I have drawn, after repeated trials, the ellipse shown on the diagram. It will be seen that it represents well all of the measured positions. The variations in distance are certainly not larger than the probable errors of the best observers, and the angles are correspondingly accurate. In the following table will be found the corrections to be applied to the observed distances. These values will not be sensibly affected by the small changes in the angles.

	″		″
1851·22	0·00	1881·98	−0·03
1855·06	−0·10	1883·00	+0·30
1864·85	−0·10	1883·80	+0·08
1865·90	+0·15	1886·34	−0·08
1869·10	−0·07	1888·12	−0·22
1873·85	+0·03	1888·94	−0·12
1877·88	+0·08	1890·89	−0·10
1879·11	+0·20	1891·78	0·00
1880·26	+0·24		

According to this orbit the angle at the time of Herschel's observation in 1783 was 324°·8, and the distance 5″·35. At the date of Struve's examination the angle would be 244°·7, and the distance 1″·70. Under the circumstances this variation in the angle is not surprising. If the small star had been seen with any certainty, it would have been measured like other difficult pairs in the *Mensuræ Micrometricæ*.

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From this ellipse we get the following elements :—

$P = 179{\cdot}7$ years. $\quad i = 69^\circ{\cdot}4$

$T = 1843{\cdot}7$ $\quad \Omega = 146^\circ{\cdot}2$

$e = 0{\cdot}142$ $\quad \lambda = 313^\circ{\cdot}9$

$a = 6''{\cdot}25$ $\quad \omega = 166^\circ{\cdot}7$

According to this orbit the distance will slowly diminish until it is little more than 2″, and then gradually increase again until the maximum of nearly 5″·4 is reached, when one complete revolution will have been described since the observation of Herschel. It happens that he discovered this pair when the distance was the greatest, and Struve observed it when the distance was minimum.

I hope observers with large apertures will regularly measure this system. The angular motion should steadily increase for some years.

Chicago:
May 24.

The Orbit of Sirius. By S. W. Burnham, M.A.

In *Monthly Notices* for 1891 April (vol. li. p. 378) I gave a list of all the measures of the companion of *Sirius*, and a diagram showing the ellipse which seemed to represent the observations as a whole as well as this could be done. I did not undertake to give from this ellipse the elements of the real orbit, for the reason that this and all other orbits of *Sirius*, down to this time, are necessarily only provisional, and roughly approximate at the best, and their interest will cease as soon as the companion can be measured again. It will then be in the third quadrant, or about 180° of position-angle, and a good set of measures at that time should fix the movement of the companion with considerable certainty. For the present all we need is the apparent orbit, in order to know about where to look for the small star. In the paper referred to I gave the period according to this orbit as fifty-three years. Dr. T. J. J. See has recently examined the original diagram, and has called my attention to an error in this quantity. I have gone over the matter carefully, and find that in some way I have made a considerable error in the period as published in my paper.

In the course of this re-examination I have deduced the remaining elements from this ellipse as follows :—

$P = 51{\cdot}97$ years. $\quad i = 50^\circ{\cdot}8$

$T = 1893{\cdot}5$ $\quad \Omega = 40^\circ{\cdot}3$

$e = 0{\cdot}568$ $\quad \lambda = 135^\circ{\cdot}4$

$a = 8''{\cdot}31$ $\quad$ Per. (app.) $= 253^\circ{\cdot}0$